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SIGHT-TESTING MADE EASY

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FOURTH EDITION

LONDON
J. & A. CHURCHILL
7, GREAT MARLBOROUGH STREET
1920

139/2

SIGHT-TESTING MADE EASY

Opinions of the Press

"*The intention of this unpretentious little manual is to enable the busy practitioner to test the sight of a patient and to prescribe correcting glasses for him. The fact that it has reached its third edition is evidence that it has supplied a real need.*"—The Lancet.

"*The little work is in every way reliable, straightforward, and clear, and we heartily recommend it as a preliminary to a perusal of more advanced works on refraction.*"—The Hospital.

"*We can recommend the book as an introduction to the subject of refraction, which, as the author tells us in his preface, is the object of his work.*"—Dublin Medical Journal.

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PREFACE

THIS little manual was originally compiled in the form of notes as aids to memory, and only dealt with Refraction in its *subjective* form. It was thought, however, to be incomplete without a few notes on the *objective* form, generally known as Retinoscopy, and these were added in a second edition. In the present edition the little book has been thoroughly revised, and in some parts re-written. It was not in its original, nor is it now, in its revised and slightly enlarged form, intended to supersede larger and more comprehensive works on Refraction, but merely to act as companion to them, and enable the busy practitioner to test the sight of a patient, and prescribe the necessary correcting glasses, in the shortest possible space of time. To the student it is hoped it may be found helpful as an introduction to the study of Refraction.

W. W. H.

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Cadogan Gardens, S.W. 3.

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ABBREVIATIONS AND SIGNS

Ax.	Axis.	p.p.	*punctum proximum.*
B.	Base.	p.r.	*punctum remotum.*
B.E.	Both eyes.	R.V.(E.)	Right vision (eye).
Cyl.	Cylinder.	Sph.	Spheric or sphere.
D.	Dioptre.	+	Convex (*plus*).
G.D.	Greatest defect.	–	Concave (*minus*).
L.D.	Least defect.	⌒	Together with.
L.V.(E.)	Left vision (eye).	→	Axis horizontal.
Mn.	Meridian.	↓	Axis vertical.

APPROXIMATE MENSURAL EQUIVALENTS

Centimetres.	Inches.	Centimetres.	Inches.	Centimetres.	Inches.	Centimetres.	Inches.
2·5 =	1	20 =	8	38 =	15	56 =	22
5 =	2	23 =	9	40·5 =	16	58 =	23
7·5 =	3	25·5 =	10	43 =	17	61 =	24
10 =	4	28 =	11	46 =	18	65 =	25½
12·5 =	5	30·5 =	12	48 =	19	70 =	27½
15 =	6	33 =	13	51 =	20	74 =	29
17·5 =	7	35·5 =	14	53 =	21	79 =	31

100 cm. (1000 mm.) = 1 metre = 39·37 Eng. in.

Metric to Imperial.

1 grm. = 15½ (15·43) gr.
1 ml. (c. cg.) = 17 (16·9) min.

Imperial to Metric.

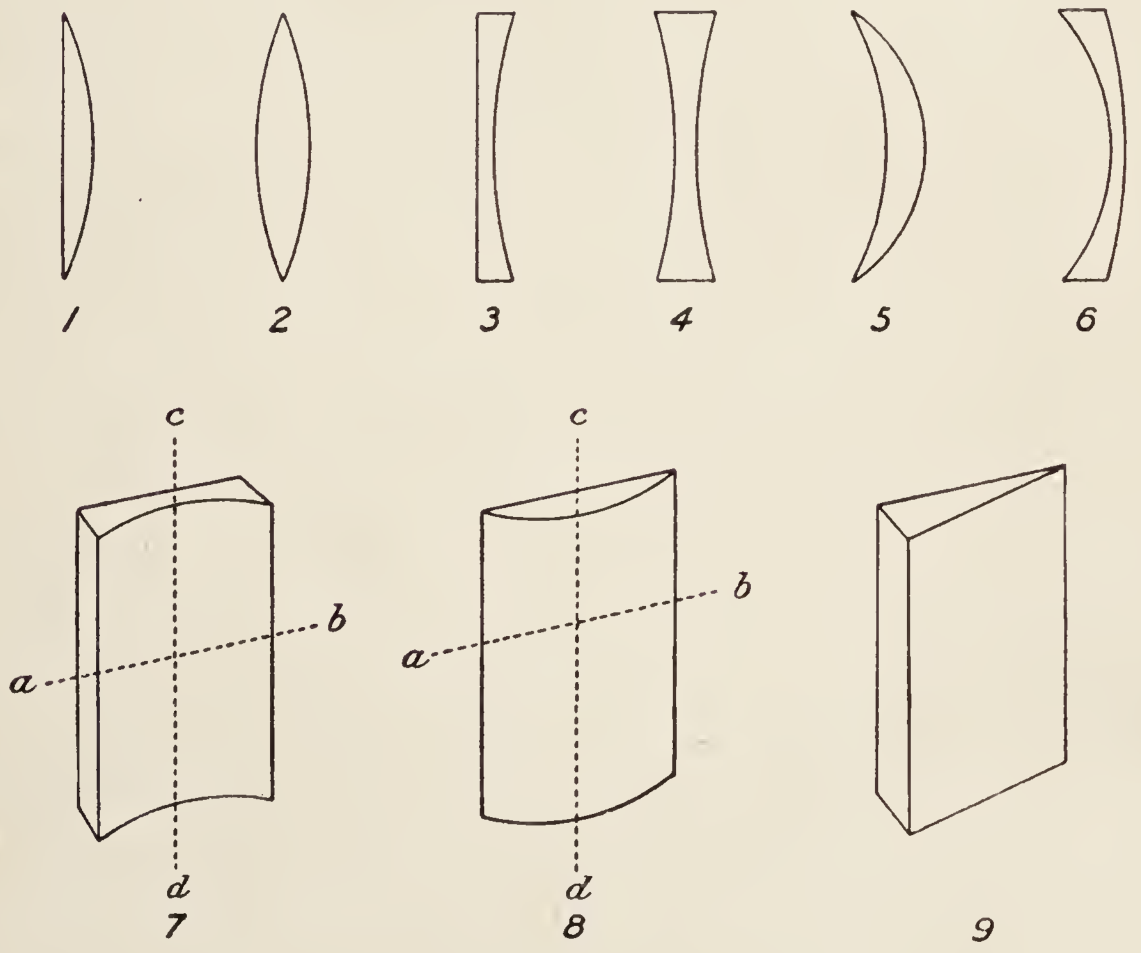
1 gr. = 6½ (6·5) cg.
1 fl. oz. ≐ 28 (28·41) ml.

PART I

REFRACTION AND OPHTHALMOLOGY

I. Lenses and Refraction.

Fig. 1.*



1. Lenses may be spherical, cylindrical, or prismatic, and may be used either alone or in

---

* Note.—The lenses numbered *7, 8,* and *9* are shown square for convenience of illustration.

combination. The former two may be either concave (—) or convex (+).

2. Spherical lenses consist of a refracting medium with two opposite surfaces, one or both of which may be segments of a sphere, all the radii being alike. They may be *plano*, *double*, or *periscopic* (περὶ around, σκοπέω I see, *i. e.* increase the distinctness of objects when viewed obliquely). In Fig. 1, *1* is *plano-convex*; *2* is *bi-convex*; *3* is *plano-concave*; *4* is *bi-concave*; *5* is *converging concavo-convex*, or *meniscus* (μενισκος a little moon); *6* is *diverging concavo-convex*. The last two are periscopic.

3. A *cylindrical* lens is a lens having one surface (usually) *plano*, while the other is the *segment of a cylinder*, all the radii being different (Fig. 1, *7*, *8*). The two principal *Mns.* are those of the greatest and least refraction, and are at right angles to each other, the intermediate Mns. increasing or decreasing in a regular ratio. The refracting power is at its maximum in the Mn. (*a*, *b*) at right angles to its axis, there being no refractive power whatever in the opposite Mn. (*c*, *d*), *i. e.* the meridian of the axis.

4. A *prismatic* lens (Fig. 1, *9*) is one in

which the refracting surfaces form an angle with each other. The deviation of a ray passing through a prism is always *towards the base.*

5. Light passes from a luminous body in straight lines, called "rays." These rays diverge, the divergence being proportionate to the distance from the luminous point; the shorter the distance the greater the divergence. If the distance is greater than 6 metres rays are assumed to be parallel.

6. A ray of light meeting a body may be *absorbed*, *reflected*, or—if able to pass through—*refracted*, and the denser the medium, the slower is the ray in passing through. When passing from a rarer to a denser medium (unless exactly perpendicular) a ray is refracted *towards* the perpendicular (of the surface of the latter); passing from a denser to a rarer medium is refracted *from* the perpendicular. When the sides of the media are parallel, the angle of deviation of the "emergent" ray is the same as the angle of the "incident" (or entering) ray; when not parallel, as in prisms, the ray is refracted towards the base, and the deviation is equal to half its angle; thus a No. 8 prism produces a deviation of the eye of 4°.

7. Parallel rays passing through a spherical lens do not continue parallel, but are refracted, converging towards a point (the *principal focus*) in the case of convex (*positive*) lenses, and diverging, and consequently never focussing at all, in the case of concave (*negative*) lenses.

8. The distance the principal focus is from the lens is termed the *focal length* or *measurement.*

9. The *principal axis* of a lens is represented by a line passing through the centre (the *optical centre*) at right angles to the surface, through which any ray passing is not refracted. But there are *secondary axes*, by which rays may pass through the optical centre, though not through the principal axis, suffering slight deviation and emerging in the same direction as they entered, but the deviation in thin lenses is so slight that they are usually assumed to pass through in a straight line.

10. Lenses are *numbered* according to their refractive power, and not, as in the old system, according to their focal length. A lens of 1 metre focus is taken as the unit or standard, and is called a *dioptre*, all other lenses being either multiples or fractions of 1 D.

11. The focal length of a lens, and the power required in a lens to produce a certain

focal length, may be estimated by dividing 100 by either. Thus a lens of 4 D. has its focus at 25 cm., and it therefore follows that a 25 cm. focus requires a lens of 4 D.

Lens Scale.

Dioptres.	cm.	Dioptres.	cm.	Dioptres.	cm.	Dioptres.	cm.
·25	400	2·25	43	5·	20	11·	9
·50	200	2·50	40	5·50	17	12·	8
·75	130	2·75	35	6·	16	13·	7½
1·	100	3·	33	6·50	15½	14·	7
1·25	77	3·25	30	7·	15	15·	6½
1·50	65	3·50	27	8·	12½	16·	6
1·75	55	4·	25	9·	11	18.	5½
2·	50	4·50	22½	10·	10	20·	5

II. Analysis and Neutralisation of Lenses.

12. Objects viewed through a moving convex lens appear to move in the opposite direction to the lens; viewed through a moving concave lens, appear to move in the same direction; and viewed through a moving prism show no movement unless the prism be rotated, but straight lines will be seen to be broken, and the break will be in the opposite direction to the base of the prism.

13. A spherical lens of either power will be recognised by the apparent movement of the object being the same in every Mn.; a sphero-cylinder, by the movement in one Mn., being more pronounced than in another; and a simple cylinder, by the movement being in only one Mn.—the axis Mn. having no focus.

14. Lenses are neutralised by opposite powers of the same degree, and this is best effected by sphericals. To neutralise a simple cylinder, find the spherical lens which neutralises in the opposite Mn. to the axis. Then prove with the cylinder. To neutralise a *sphero-cylinder*, find the spherical lens which neutralises in one Mn., then do the same for the other. The cylindrical part of the combination is denoted by the difference in strength of the two sphericals, the spherical part being the weaker of the two sphericals; thus, if in the horizontal Mn. we find sph. + 0·5, and in the vertical Mn. sph. + 1·0, the prescription would be, sph. + 0·5 ◯ cyl. + 0·5, ax. h. Then prove with the spheric and the cylinder.

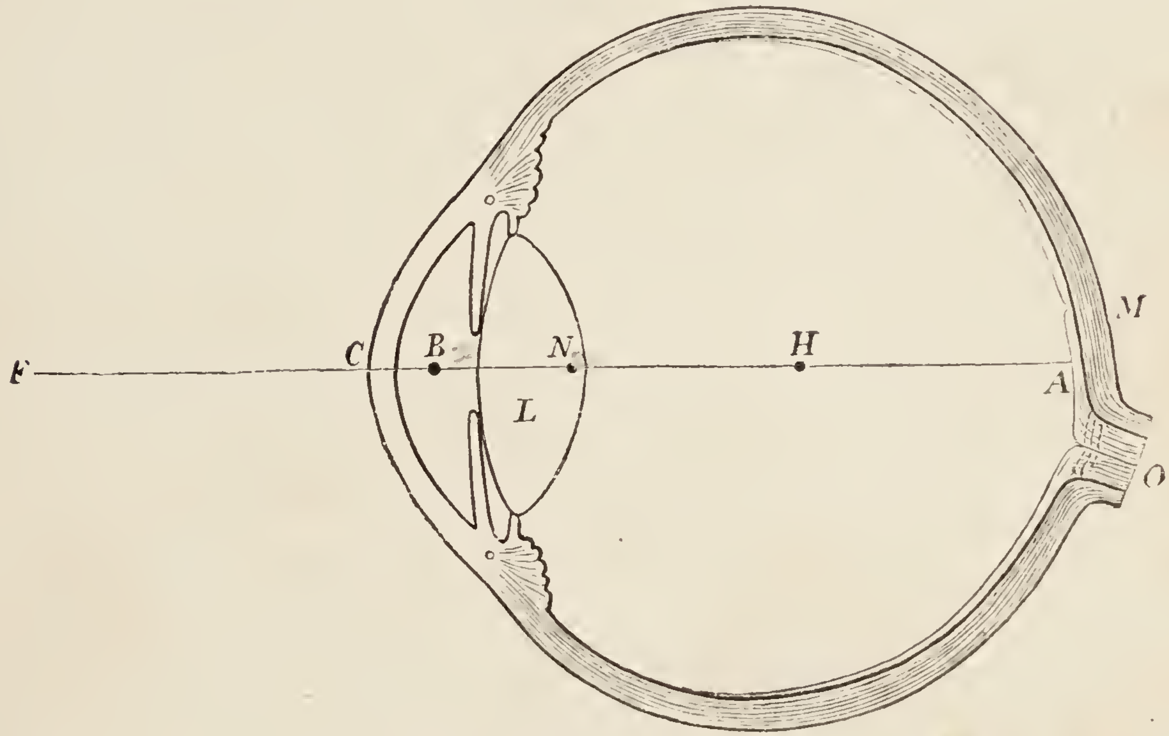
15. In prism combinations the spherical and cylindrical lenses must be first discovered, when the degree of the prism can be found by placing the lens and its neutralising refractive

element together, and looking through them at the prism scale (Fig. 12).

III. The Refractive or Dioptric System.

16. This system is a compound one, made up of a spherical surface and a bi-convex lens, together being equal to about 23 mm. focus.

Fig. 2.



(From Hartridge.)

It consists of three refracting surfaces—the anterior surfaces of the cornea, the lens, and the vitreous respectively; and three refracting media—the *aqueous*, the *lens*, and the *vitreous*.

17. There are six *cardinal points* of the eye: two *principal points*, two *nodal points*, and two *principal foci*, all situated at the optic axis (21).

18. The two *principal points* (Fig. 2, *B*) are situated close together in the middle of the corneal chamber, about 2 mm. behind the cornea. For all practical purposes they may be considered as one.

19. The two *nodal points* are situated close together, within the lens and close to its posterior surface (Fig. 2, *N*), about 7 mm. behind the cornea, and 15 mm. in front of the *macula* or yellow spot—the most sensitive part of the retina. They also may be considered as one.

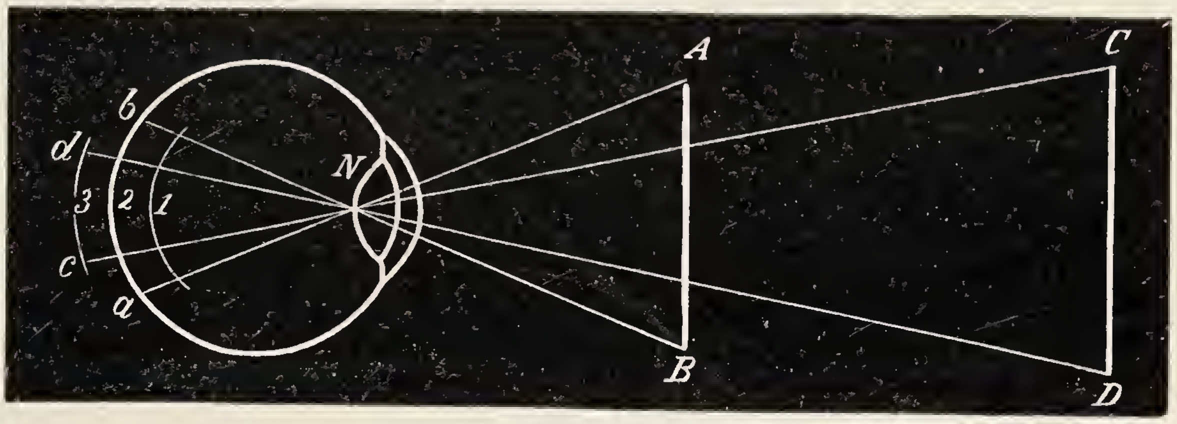
20. The *principal foci*.—The *first principal focus* (*F*) is situated about 13·7 mm. in front of the cornea, and is that point on the axis where rays, parallel in the vitreous, meet. The *second principal focus* (*A*) is 22·8 mm. behind the cornea, and is the point on the axis where parallel rays meet after passing through the eye.

21. The *optic axis* (Fig. 2, *F A*) is the line passing through the centre of the cornea, the nodal point, and the centre of rotation (*H*) 9·8 mm. in front of the retina, to the inner side of the *macula* (*M*).

22. The *visual axis* is a line passing from the macula through the nodal point to the object looked at.

23. The *visual angle* (Fig. 3, $C\ N\ D$) is the angle formed at the nodal point (N), being part of a triangle having its base at the object looked at ($C\ D$). The size of the angle depends upon the size and the distance of the object; thus an object at $A\ B$, which is as large as one at $C\ D$, but nearer to the eye, will be seen under a larger angle, the angle $A\ N\ B$ being greater than the angle $C\ N\ D$. The size of the image also, formed on the retina, will depend upon the antero-posterior diameter of the eyeball, it being smaller at 1, when this diameter is less, as in hypermetropia, than it is at 2, as in emmetropia, and larger than either at 3, as in myopia, when the eyeball is elongated. A patient may, therefore, be ~~un~~able to read the smallest type and still have some defect of refraction, unless the type be read at its proper distance.

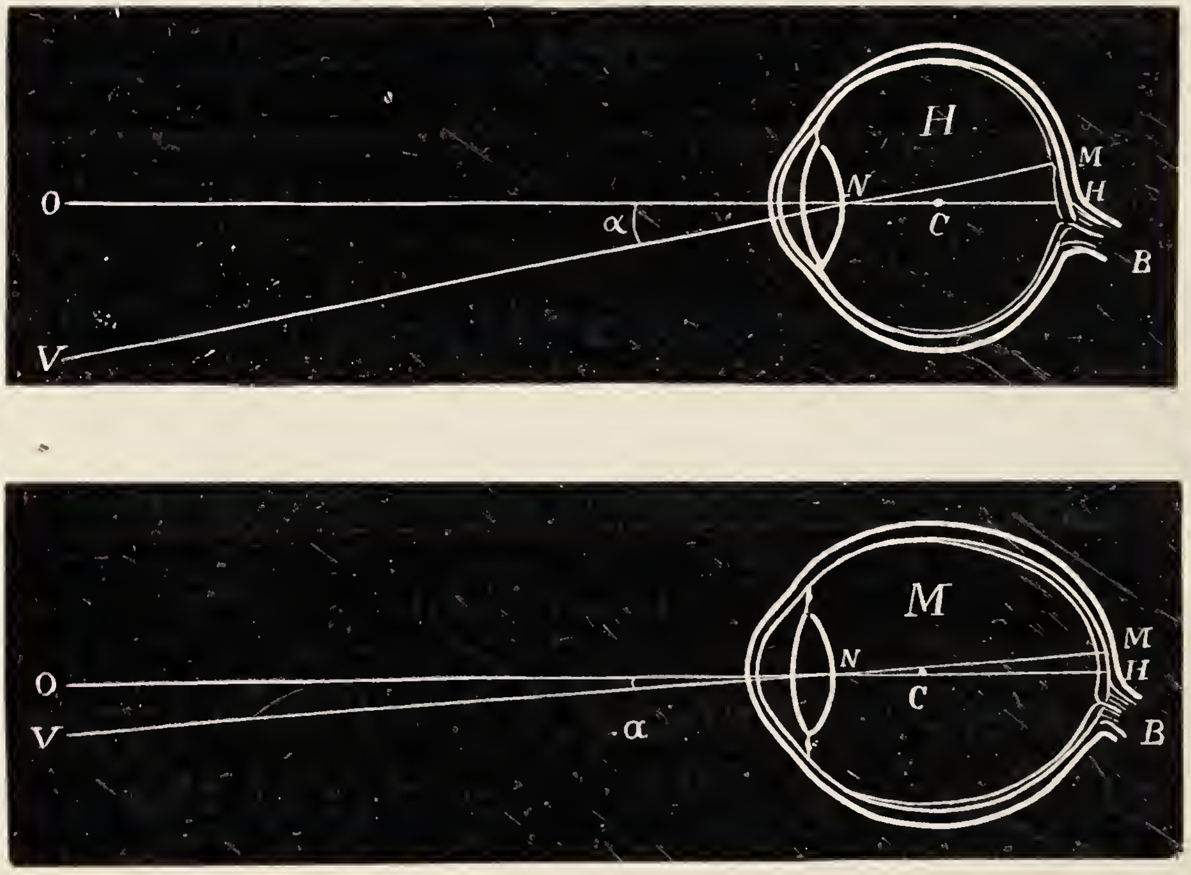
Fig. 3.



(From Hartridge.)

24. The *angle* α, of interest in strabismus, is the angle formed also at the nodal point, but by the crossing of the two axes, viz. the optic and the visual. In emmetropia (26) this angle is usually about 5°. In hypermetropia (Fig. 4, *H*), owing to the shortening of the antero-posterior diameter of the eyeball, and the divergence of the visual axes, it is greater. In myopia (Fig. 4, *M*) the angle is less, owing to the lengthening of the antero-posterior diameter and the convergence of the visual axes.

Fig. 4.



(From Hartridge.)

IV. Normal Vision and Accommodation.

25. For normal V. to exist it is necessary that the axial length of the eyeball and the focal length (8) should be the same. When there is the slightest want of harmony between these—either owing to the shape of the eyeball or the cornea, or to any defect in the accommodative apparatus, it is necessary for optical aid to step in.

26. By *accommodation* is meant the exercise of that involuntary power possessed by everyone whose refraction is normal, *i. e.* the emmetrope (ἐμ within, μέτρον measure, ὤψ the eye), and which enables the subject to see objects between the p.p. or "near point" and the p.r. or "distant point" at infinity. It is the power of altering the focus, *i. e.* of unconsciously adapting the shape of the crystalline lens (intra-ocular), and the position of the axis of the eyeball (extra-ocular) to the varying conditions to which the eyeball is subject. When accommodation is defective and parallel rays are focussed behind or in front of the retina, the condition is termed *ametropia* (α priv., μέτρον measure).

27. For refraction to be normal, the parallel rays entering the eye through the pupil and

passing through the refractive media unite exactly on the retina at the second principal focus.

28. During accommodation, the convexity of the lens is altered by the action of the ciliary muscle, which, contracting, draws forward the choroid, thereby relaxing the suspensory ligament and allowing the elasticity of the lens when looking at near objects to come into play.

29. During distant V. the accommodative power is at repose, the optic axes being parallel or, more usually, slightly divergent, but immediately the visual axes are directed to a point nearer than infinity, extra-ocular accommodation (the internal recti muscles) acts in unison with intra-ocular accommodation (the ciliary muscle), and convergence is brought into use, by which the maculæ of both eyes are directed towards the same point, so that images received upon the retina of each eye are blended into one, and singleness of V. is produced. If any defect, or want of harmony in the association of the different parts of the accommodative apparatus —as, for instance, when the image is formed on parts of the retina which do not exactly correspond in the two eyes—exists, *diplopia*

(διπλόος double, ὤψ the eye), and eventually *asthenopia*, results.

tends to go [illegible]

30. The p.p. is the nearest point of the range of accommodation at which objects can be seen distinctly. It recedes gradually as age advances. When it has receded beyond 22 cm., which it does about the age of forty-five, *presbyopia* occurs. The p.r. is at infinity. The space between the p.p. and the p.r. is termed the "range of accommodation"; and the force necessary to change the eye from its p.r. to its p.p. (irrespective of the refractive condition of the eye) is a fixed quantity, the same in emmetropes, hypermetropes, and myopes, and is termed the "amplitude of accommodation."

31. *Amplitude of Accommodation.*

(Taken from Duane.)

At age.	D.	P.p. (cm.).	At age.	D.	P.p. (cm.).
10	14	7	40	6	17
15	13	7·5	45	4	25
20	11·5	8·5	50	2·5	40
25	10	10	55	1·5	75
30	8·5	11·5	60	1·3	80
35	7·5	13	70		

32. To measure the amplitude of accommodation in the *Emmetrope*, we find the nearest

point at which the patient can read small type. A lens, the focal distance of which corresponds with this, is the measure. For instance, if the nearest distance at which a patient can read small type is 20 cm., we divide this distance into 100 cm. and divide by 20, by which we get 5 D., which is the measure of the amplitude of accommodation. In *Hypermetropes* we add on the number of the convex lens which enables him to see distant objects without his accommodation. For instance, if his p.p. is 25 cm., 100 divided by 25 gives 4 D.; and assuming that he has to use a 4 D. of accommodation, then the amplitude of accommodation would be 4 D. + 4 D. = 8 D. In *Myopes* we subtract his lens power for distant objects; for instance, in a Myope of 2 D., the p.p. being at 10 cm., if we divide 100 by 10 c.m., the result is 10 D., from which we subtract 2 D., which leaves 8 D. as the amplitude of accommodation. At age 75 all power of accommodation has practically ceased.

V. Asthenopia.

33. *Asthenopia* (ἀσθενής weak, ὤψ eye), or eye strain, may be accommodative or muscular. *Accommodative asthenopia*, or fatigue of the

ciliary muscle, is generally associated with hypermetropia or hypermetropic astigmatism, less frequently with myopia. In the former cases it is due to the excessive use of that muscle where errors of refraction exist uncorrected, and hypertrophy of the ciliary occurs. The overstrain may produce tonic spasm, when myopia is simulated.

34. *Muscular asthenopia*, or fatigue of the extra-ocular muscles producing latent imbalance or disturbance of equilibrium (*heterophoria*) is most common in adults, but may occur in children during the educational period. When the muscular imbalance exceeds a certain degree, as is the case in converging and diverging strabismus, *diplopia* is the result. Normally the two eyes are in a state of perfect equilibrium (*orthophoria*), the adjustment being so fine as to allow of the images of objects appearing exactly on the same spot of each retina.

35. The *symptoms of asthenopia*.—HEADACHE, and acute pain in the eyes or orbits; the more acute it is, the more does it point to asthenopia. The pain is increased when the eyes are used for near objects, but sometimes there is no pain, and at others it is referred to the back of the neck; the type becomes indistinct or double

and blurred, and the patient rubs his eyes. There is photophobia, lacrimation, and more or less conjunctival congestion with blinking of the eyelids, which become red and irritable. The symptoms are always accentuated after a day's work, especially if artificial light has been used. In children headache comes on shortly after commencing school work accompanied by blinking of the eyelids.

VI. HETEROPHORIA.

36. Heterophoria (ἕτερος different, φορεω I bear) or muscular imbalance may manifest itself in either eye as *esophoria* or latent ~~di~~vergence, Co *exophoria* or latent divergence, or *hyperphoria* or latent deviation upwards. They are all forms of muscular asthenopia. Such cases are better referred to an ophthalmic specialist.

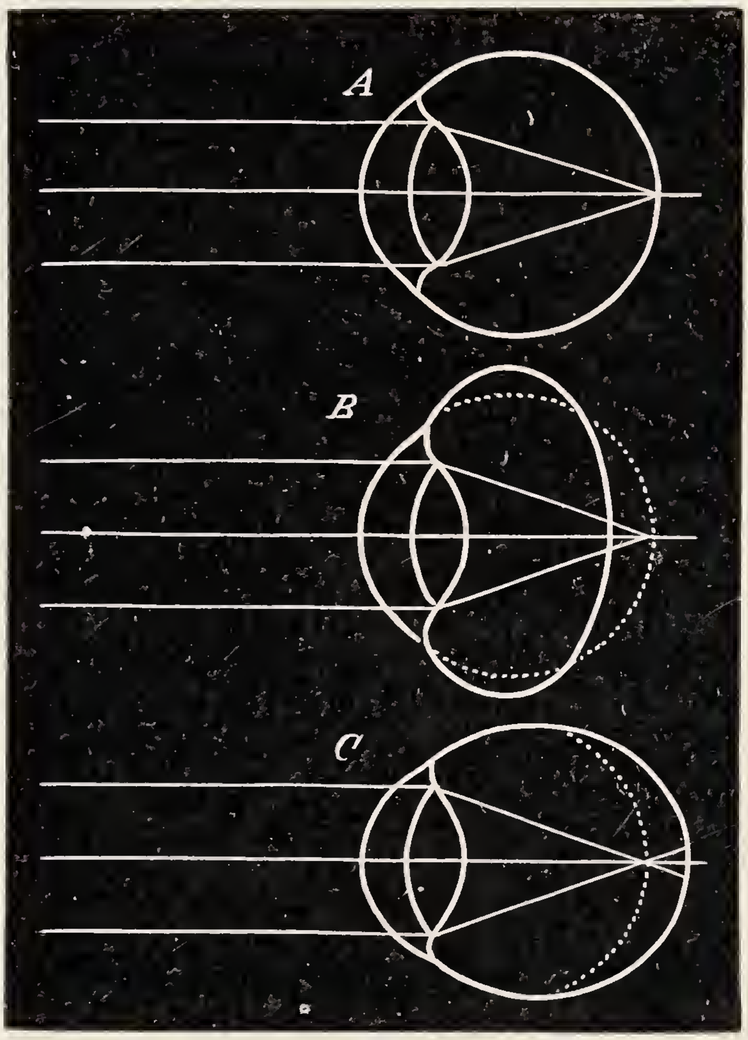
37. *Esophoria*, usually associated with, and often caused by hypermetropia (frequently latent), is seldom met with according to Hartridge, though common, as it quickly passes on to convergent strabismus.

38. *Exophoria*, the commonest of these defects, is most frequently associated with myopia. The tendency of the eye to turn outwards is acused by inability to maintain the prolonged

convergence necessary to perfect vision, from insufficiency of the internal recti muscles.

39. *Hyperphoria*, or latent deviation upwards of one eye, is caused by insufficiency of the oblique muscles. It is usually associated with esophoria, but may exist alone. It is a common defect.

Fig. 5.



A. Emmetropic eye. B. Hypermetropic eye. C. Myopic eye. (From Hartridge.)

40. The *symptoms of heterophoria* are those of asthenopia in general. Want of harmony between the functions of convergence and

accommodation is a frequent source of HEADACHE, and if it persists after application to near work, when the visual acuteness is normal, heterophoria may reasonably be suspected.

VII. HYPERMETROPIA.

41. All eyes at birth are hypermetropic (ὑπερ above, μέτρον measure, ὤψ eye), the ocular development being incomplete until the age of puberty; hypermetropia is therefore more common than myopia. In hypermetropia this natural development has been arrested, with the result that the axial length (of the eyeball) is less than the focal length (of V.); in other words the eyeball is too short, the parallel rays of light being brought to a focus behind the retina (Fig. 5, *B*). The higher the degree of hypermetropia, the further from the eye is the p.r.

42. Hypermetropic children should not be allowed to use their eyes for near sight till proper correcting glasses can be used with safety, *i. e.* at the age of four or five years. As some diminution in degree may be looked for, the sight should be tested every two or three years, with a view to reducing the strength of

the lenses. But after adult life is reached no change is likely to occur, though the defect will not be likely to increase.

43. In young hypermetropes there is frequently a certain amount of *latent* hypermetropia hidden behind the strong accommodative effort which can only be discovered under atropine. And if—where atropine has not been used—the hypermetropia is found only to be partially corrected, that the above exists may be looked upon as a certainty.

44. The *symptoms of hypermetropia.*—Distant V. is good. There is difficulty in reading long together, especially in the evening. After reading for some time the type becomes indistinct, and the eyes ache. Headache, nausea, and sometimes vomiting, all of which symptoms pass off after a night's rest. Hypermetropes usually have small eyes and pupils.

45. In prescribing glasses for reading in hypermetropia, it is advisable to fully correct the *manifest* hypermetropia whilst giving one third only of the correction for the *latent* hypermetropia discovered under atropine.

46. In young persons whose hypermetropia does not exceed 3 or 4 D., and distant vision is good without glasses, these need only be worn

for reading or near work. But when this is exceeded or when hypermetropia is complicated with convergent concomitant strabismus, glasses should be worn constantly.

47. A hypermetrope of over forty years of age will be presbyopic also. The reading test must therefore be applied. The correction for the distant vision only (the hypermetropia) should be worn constantly.

48. In hypermetropes the ciliary muscle becomes hypertrophied owing to its excessive use, thus overcrowding the ciliary region, with the consequence that *glaucoma* is most common in hypermetropic eyes.

49. Where atropine is not used, and especially in the young, with whom the accommodative effort is very strong, hypermetropes will sometimes, owing to ciliary spasm, prefer a concave to a convex lens, the explanation being that the concave lens exercises a stimulative effect on accommodation, producing a temporary false myopia.

VIII. Myopia.

50. In myopia (μύω I close, ὤψ the eye) the axial length is greater than the focal length—in other words, the eyeball is too long, with

the result that the parallel rays are brought to a focus in front of the retina (Fig. 5, *C*). In order to see near objects the eyes must converge, with the result that, when reading, the book is held close to the eyes; and if this convergence be not counteracted ultimate blindness may ensue.

51. Myopia is seldom or never congenital, but shows itself generally about the eighth year. The earlier it appears the greater the tendency to increase and the more serious it is, and when corrected there is no certainty that the defect will not increase. When it shows itself after school life the tendency to increase is not so great, but when it increases after adult life it is very serious and is then termed *progressive myopia.*

52. Myopia is the most serious of all errors of refraction. In the higher degrees (above 6 D.) pathological changes are apt to occur in the eye which frequently end in destruction of vision. The backward compression of the globe by the extra-ocular muscles, produced in the instinctive endeavour by the patient to improve the distant vision by cutting off the divergent rays, and by excessive convergence which is resorted to for near work, is apt to

produce atrophy of the choroid. Myopes, however, enjoy an almost complete immunity from *glaucoma* because of the atrophy of the ciliary muscle due to the comparative lack of its use.

53. The *symptoms of myopia.*—Distant V. is defective, but there is no discomfort with near work, though the object is held nearer than normal. V. at night is bad. Sparks, circles, flashes of light, etc., may be seen. Straight lines appear bent or broken. There is nearly always *photophobia.* Headache is unusual, and the eyes and pupils are usually large. In low degrees, and when uncomplicated with astigmatism, there is no *asthenopia.* When the presbyopic period is reached the myopia is neutralised by the *presbyopia*, and the patient is able to read without glasses.

54. A cycloplegic is always advisable in the young in case the defect from spasm of the accommodation might appear greater than it really is, and thus the full correction be exceeded. Where it is not used the defect must be under-corrected. Over-correction in all cases of myopia is to be avoided.

55. Glasses are absolutely necessary, not only for near V. for the purpose of compelling the patient to read farther away, but

also for distant V. Where examination of the distant V. indicates a low degree of myopia, spasm of the ciliary may be suspected, when retinoscopy should be practised before any glasses are ordered, and if a myopic shadow be found the patient should be atropised and re-examined.

56. The reading distance for a myope should be about 35 cm. (14 in.). For those whose distant V. is – 4 D. and upwards, two-thirds less power in the concave lens should be provided for reading. As the lenses of the glasses will be worn nearer the eye than are those in the trial frame, they should be about ½ D. less in power for every 5 D. of myopia. A myope of 3 D. will not require glasses for reading, as his p.r. is at 33 cm., but by encouraging young myopes to wear suitable glasses we improve the tone of their ciliary muscles. If he has 6 D. of myopia he will require – 3 D. in order to put back his p.r. from 16 cm. (6½ in.) to 33 cm. The higher the myopia the nearer to the eye is the p.r.; but the p.p. is determined by the amount of accommodation.

57. In *progressive myopia*, if the myopia increases rapidly with irritation, complete rest must be given to the eyes, and solution of

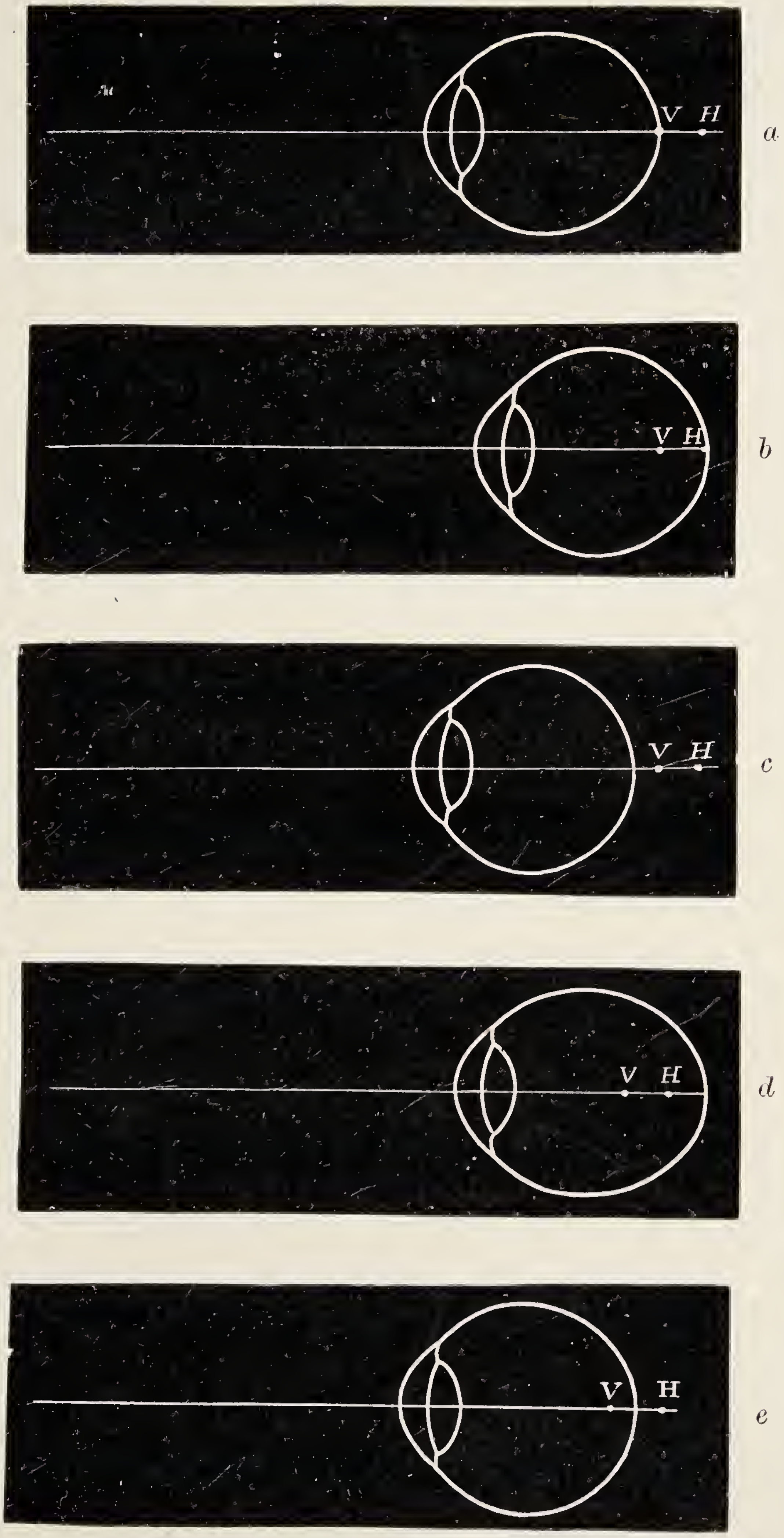
atropine (6 cg.–28 ml.) be dropped between the lids three times a day for two or three weeks; counter-irritation may also be applied to the temples or behind the ears. No glasses should be worn except smoke-coloured protectors. Reading should not be allowed until the irritation has subsided, and then only for a short time in a good light, the eyes still being atropised.

IX. ASTIGMATISM.

58. In astigmatism (*α* priv., *στίγμα* point) there is a difference in the refraction of the different Mns. of the same eye, owing to the deviation from the normal curvature of the dioptric surface. The fault may be either (1) at the lens, or (2) at the cornea; and may be *congenital*—when the defect is generally symmetrical in both eyes, or *acquired*. (1) When the fault is at the lens it is nearly always congenital; but this organ may be dislocated, when it is acquired. (2) When the fault is at the cornea—which is generally the case—it may be due, congenitally, to unequal shape or to *conical cornea;* pathologically, to *nebula;* and when acquired, to wounds or ulceration.

59. Astigmatism exists to some extent in

Fig. 6.



(From Hartridge.)

nearly all eyes, but if only to such a small extent as not to disturb V. does not require optical aid.

60. *Regular astigmatism* (Fig. 6) consists of (1) *simple*, wherein one Mn. is defective, either hypermetropic (*a*) or myopic (*b*), the former being the most common; (2) *compound* where both Mns. are defective, either hypermetropic (*c*) or myopic (*d*), but in different degrees; (3) *mixed* (*e*), where both Mns. are defective—one hypermetropic, and the other myopic.

61. The *symptoms of astigmatism* are those of asthenopia in general. The head is frequently noticed to be held on one side when an object is looked at, with the nose away from the object. In mixed astigmatism the patient usually has a vacant look, and screws up his eyes when looking at an object.

62. There are two principal Mns. in astigmatism always at right angles to each other. They are the Mns. of *greatest* and *least defect* (G.D. and L.D.), and it is upon the discovery of the former in hypermetropia and of the latter in myopia that the accuracy of our diagnosis, and correction, depends.

63. The Mn. in which the patient sees best with the *strongest convex* lens is that in which

he sees worst with the naked eye; it is therefore the Mn. of greatest defect. The Mn. in which he sees best with the *weakest concave* lens is that in which he sees best with the naked eye, and is the Mn. of least defect.

64. It must be understood that the Mns. are always those of the card or dial, and not of the eye. Glasses are adjusted according to the former, which are the opposite to what the Mns. of the eye would be found to be under the objective test of *retinoscopy*.

65. In describing the Mn. in which the greatest refractive defect is found and in which the axis of a cylindrical lens is to be placed, the degrees of half a circle, *i. e.* from 1° to 180° are used, these being alone necessary, for the Mn. of 1° is the same for purposes of refraction as 181° (see Fig. 8). The horizontal and vertical Mns., 0° and 90°, are described as *h* and *v* respectively, and not by the number of the degree. These Mns. are by some represented by a horizontal or vertical arrow, instead of by the abbreviations *Ax. h.* or *Ax. v.*

66. The greatest curvature and consequently the greatest refraction in the astigmatic eye, as in the normal eye, is usually in the vertical Mn.; the least in the horizontal Mn. But

there are exceptions to this, and when these exist the astigmatism is said to be "against the rule."

67. In all forms of astigmatism, the horizontal Mn. is generally the hypermetropic one, and the vertical the myopic one; consequently, in hypermetropic astigmatism the axis of the correcting cylinder is generally required to be placed vertically, and in myopic astigmatism, horizontally. In simple hypermetropic astigmatism the vertical Mn. is emmetropic.

68. On wearing suitable glasses improvement is not always at first perceptible, especially in mixed astigmatism (though generally at once apparent in hypermetropic astigmatism); in fact, for the first two or three weeks the glasses may be worn only by an effort, and may even increase the discomfort until the eye becomes accustomed to them.

69. *Irregular astigmatism* exists where the curvature in any single Mn. is not everywhere alike, so that the rays passing through the same Mn. are never united in one point. When congenital the lens is usually in fault (*incipient cataract*); when pathological, it is usually the cornea (*conical cornea* or *ulceration*). This condition cannot be corrected by glasses.

70. *The stenopaic slit* is a disc having a

narrow, oblong opening in it, and may be found useful in diagnosing cases of astigmatism. It is rotated in the trial frame while the patient looks steadily at the distant type, and the Mn. in which the best V. is obtained noted. We then try the defective Mn., first with spherical convex, and then with concave lenses placed in front of the disc. Example: Supposing, with the slit in the vertical Mn., V. is $\frac{6}{6}$, but with convex lenses is indistinct, the vertical Mn. is emmetropic. Place it in the opposite Mn.—the horizontal—and V. is found to be $\frac{6}{12}$, but with sph. + 2·0 V. is $\frac{6}{6}$, the horizontal Mn. is hypermetropic, the case being one of simple hypermetropic astigmatism, requiring for correction cyl. + 2, ax. v.

X. Presbyopia.

71. Presbyopia (πρεσβυς old, ὤψ eye) is not a pathological condition but a physiological process, due to advancing years, in which there is gradually diminishing loss of the power of accommodation. There is loss of elasticity in the lens, with loss of the power which it possessed of increasing its convexity, and to some extent loss of power in the ciliary muscle, with consequent gradual recession of

the p.p. The lens gradually increases in size, and, approaching the cornea, becomes somewhat flatter. The result is that near objects are not seen so clearly as formerly.

72. Presbyopia generally manifests itself at forty-five years of age or thereabouts, when the p.p. has receded beyond the distance at which we are accustomed to read or write with comfort (30 to 40 cm.); in hypermetropia, earlier; in myopia, later. An emmetrope will never require a stronger lens than + 3·5, because these lenses adapt him for a distance of 30 cm. without any accommodation. At the age of forty the eye of the emmetrope possesses just that amount of refractive power which enables him to see at 22 cm.

73. *Symptoms of presbyopia.*—Gradually increasing sense of fatigue after reading, due to presbyopic asthenia; and a feeling as if there were not light enough.

74. The lenses for presbyopia ought to give distinct V. only, and not magnify; they also ought first to be used only by artificial or insufficient light for very fine work (145).

Presbyopia with Hypermetropia.

75. Hypermetropes generally are more pres-

byopic than emmetropes at the same age, and therefore require stronger lenses.

76. The lenses which correct the hypermetropia only should be worn constantly, the presbyopic correction, for reading only.

Presbyopia with Myopia.

77. Owing to the gradual recession of the p.p. with advancing age, in myopia it will be longer in reaching the point (22 cm.) when presbyopia commences than in the emmetrope, so that in prescribing glasses for presbyopes the amount of myopia has to be deducted from the lens which the emmetrope would require at any given age.

78. It is only myopes under 3 D., whose p.p. has receded beyond 33 cm., who may require convex lenses for reading while still requiring concave lenses for distance, and then only late in life.

79. A myope of 2·5 D. has his p.r. at 40 cm.; one of 2 D. at 50 cm.; one of 1·5 D. at 65 cm.; and as these two last are not comfortable distances for reading, convex glasses become necessary. A myope of 1 D. at age 50 will, according to the presbyopic scale (144), have a presbyopia of 1 D.; consequently one will

neutralise the other, and he will require no glasses.

XI. STRABISMUS.

(*Although strabismus does not come within the scope of subjective sight-testing, a few notes on the subject may not be unacceptable to the reader.*)

80. STRABISMUS (στραβισμός squinting) exists where, owing to the disturbed muscular equilibrium of one eye, the deviation in its direction is such that the visual axes of the two eyes are not directed to the same object, with the result that the image of the object is not received by the maculæ of both eyes, and binocular vision is rendered impossible. It may be due to defective anatomical conditions, or—which is more common—to abnormal innervation, causing contraction of the extra-ocular muscles, and so excessive convergence or divergence.

81. *To diagnose the squint.*—Hold the finger up about a yard in front of the patient, and direct him to fix his eyes upon it. Then gradually approach him with the finger, so as to call into action his accommodation. (*a*) If both eyes steadily follow the finger there can

be no squint, and it is only *apparent*. (*b*) If one eye follows the finger, while the other, after following it up to a certain distance, suddenly deviates inwards or outwards, *concomitant strabismus*, convergent or divergent, is diagnosed. But the squinting eye follows the fixing (non-squinting) one in all its movements, the visual axles maintaining the same relation to each other in whichever direction the eyes are turned. (*c*) If both eyes follow the finger up to a certain point, where one eye stops "after making a few jerking, oscillatory movements," move the finger up and down and from side to side about 45 cm. from the patient. If the squinting eye stops at a certain point, while the other (the fixing) eye continues to follow the finger, *paralytic strabismus* is diagnosed. The movements of the squinting eye in this variety are usually very limited. There is always *diplopia* in this variety, but seldom in the concomitant variety, because the false image seen by the squinting eye gradually becomes suppressed.

Concomitant Strabismus.

82. In concomitant strabismus one eye is generally directed inwards—*convergent*, or out-

wards—*divergent*, but sometimes these are combined with a slight upward or downward tendency. The former is the most common form. [illegible]

83. Squint is not present at birth and never exists in both eyes at once. It generally makes its appearance about the fourth or fifth year, as soon, in fact, as the child begins to look at near objects, and is generally convergent.

84. But squinting is liable to occur normally in infancy, before the brain centres and the visual faculty are sufficiently developed, and whilst the eyes are being educated for binocular vision. And the tendency may be aggravated by teething and other disturbances of the general health. Infantile squinting, however, disappears in the majority of cases. But if, after arriving at a year old, the squinting still persists it is abnormal, and should receive immediate attention. If neglected, the squinting eye, being but little used, will become *amblyopic* (ἀμβλυς, dull) in time.

85. Squinting may be *alternating*—when sometimes one eye becomes the fixing one and sometimes the other, indiscriminately; *constant* —when the same eye always squints; or

periodic—when the squinting eye only deviates occasionally. The last form may with careful treatment be cured without an operation (92); if neglected, it generally lapses into the constant form.

86. In *convergent strabismus* the image is received on the inner side of the macula of the squinting eye, and the image is projected to the *temporal* side of the real object. In *divergent strabismus* the image falls on the *temporal* side of the macula, and is projected to the *nasal* side of the object. In the upward variety the false image is projected *below*, and in the downward variety, *above*.

87. The greater the deviation of the eye the further apart are the images, and the less distinct the false image.

88. *Convergent strabismus* is intimately connected with, and usually caused by, hypermetropia. The convergence exceeds the accommodation, and is most marked when looking at near objects. It is usually in cases of from 2 D. to 4 D. that convergent squint is most frequently met with.

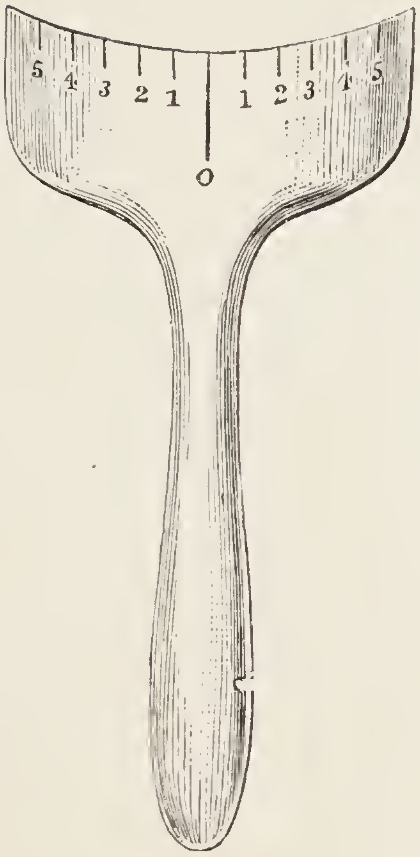
89. *Divergent strabismus* is not so common as the convergent variety. It is usually due to myopia, in which condition the extreme con-

vergence necessary to enable the patient to see objects within the range of his far point produces an asthenopic condition of the internal rectus, which, becoming fatigued, gives way, and the eye deviates outwards.

90. *To estimate the degree of the squint.*—The usual method is to make an ink mark on the lower eyelids of both eyes immediately below the centres of the pupils. Hold a card in front of the fixing eye, when the squinting eye will at once make a movement outwards or inwards, as the case may be, to fix the object; a second mark is then made as before below the squinting eye in its new position. The difference between the two marks represents the amount of the squint. This is called the *primary deviation.* But while the squinting eye was deviating to fix the object, the fixing eye behind the card will also have deviated in the same direction as the squinting eye. This is the *secondary deviation.* And a second mark is now made below this eye in its new position, when the deviation will be found to equal exactly that in the squinting eye, which is a characteristic of concomitant squint, whereas in paralytic squint the secondary deviation exceeds the primary.

91. The deviations represented by the ink-marks are now measured with the strabismometer (Fig. 7), which is placed below the lower eyelid, when the degree of the deviation can be read off. If great exactness be required the perimeter may be used, by which the angle of the squint (*i. e.* the angle which the visual axis makes with the direction it should take normally) may be measured.

Fig. 7.



Strabismometer.

92. *Treatment.*—Young children should be discouraged as much as possible from looking at near objects. Any error of refraction is

to be corrected to prevent excessive accommodation, and equalise the two functions of accommodation and convergence. In slight cases, if the squint disappears under atropine, glasses will probably effect a cure, but they must be worn for some months. Tying up the fixing eye for an hour or so a day is found useful. Mr. Hartridge recommends the application of 1 drop of a $\frac{1}{2}$ per cent. solution of atropine to the fixing eye twice a week to prevent this eye being used for near objects, and to compel the deviating eye to be employed for this purpose; and says that "in *periodic* strabismus, where squinting has only just commenced, and arises only under the influence of excessive accommodation necessary to enable the child to see near objects, this treatment may at once correct the deviation." Glasses for constant use may then only be necessary for a year or two, but must be continued for near work for a much longer time.

93. When the squint has become permanent, glasses may have to be worn constantly for many years.

94. When children under three years of age are ordered glasses, parents should be cautioned as to the danger attending their use.

95. Before glasses are used, the eyes should be examined objectively by retinoscopy under atropine, in order that the refractive condition may be accurately estimated, and the proper correcting lenses supplied for constant use.

96. When normal V. is not obtained after correction, muscular exercises must be adopted, and the development and cultivation of the visual faculty carried out by stereoscopes or Worth's amblyoscope.

97. If, after seven years of age, but not before, glasses have been worn for some months, and no improvement is manifested, operative interference will be necessary.

98. In divergent squint with myopia, the full correction should be given for constant use. But "when divergent squint is developed, the only successful treatment is operation" (Jessop).

PART II

SUBJECTIVE SIGHT TESTING.

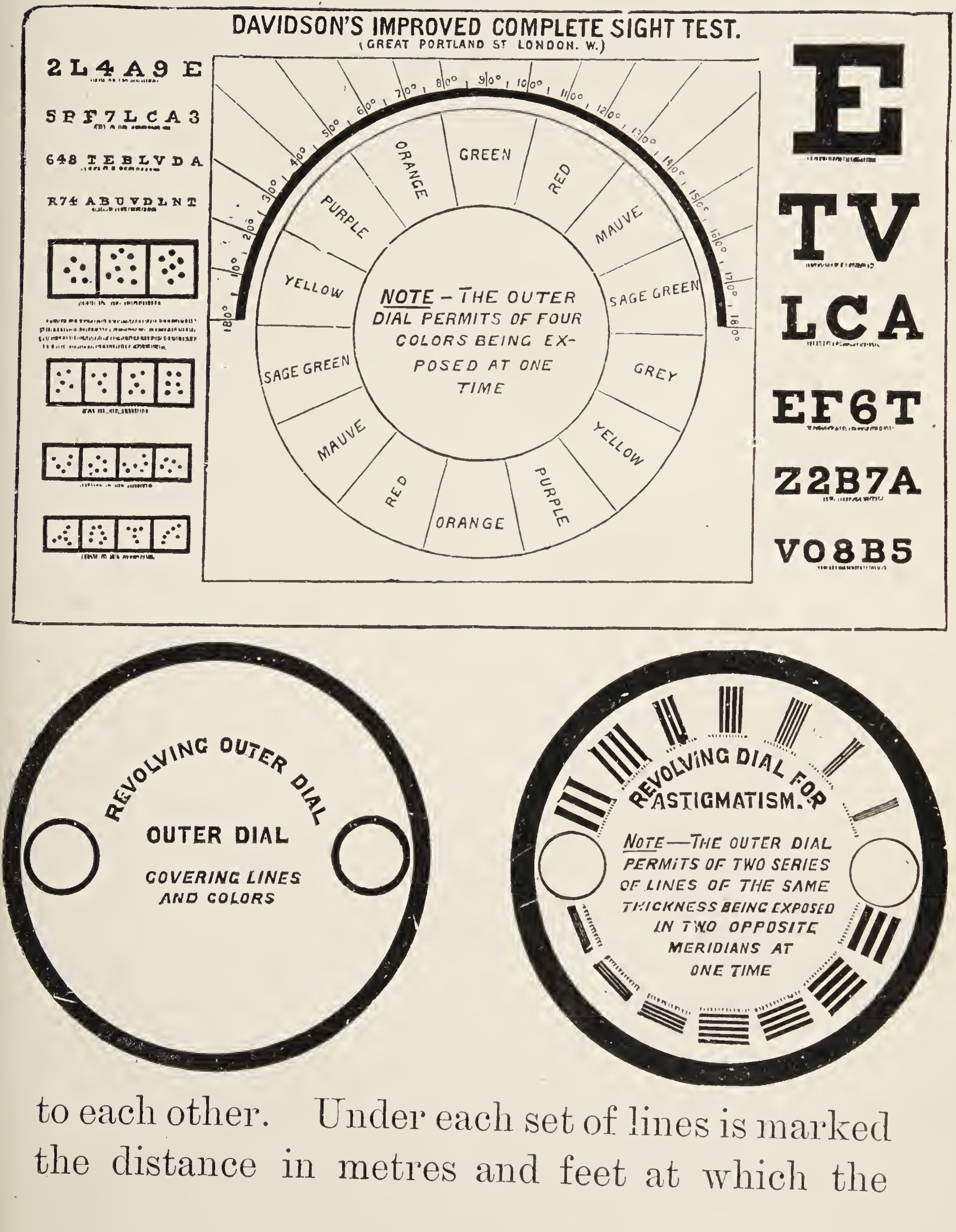
XII. PRELIMINARY NOTES.

General.

99. The student should provide himself with a complete set of trial lenses, consisting of two sets each of the following: Convex and concave sphericals, from ·25 to 4·0 in quarters, from 4·0 to 6·5 in halves, and from 7·0 to 10·0 in complete dioptres. Convex and concave cylindricals from ·25 in quarters to 4·0. One set of ten prisms, pin-hole disc, stenopaic slit, Maddox rods in reversible frame, and adjustable trial frame. Also a metric measure, and a sight test card similar to that shown in Fig. 8, revolving in the centre of which are two circular dials. The card should be hung so that the centre is as nearly as possible on a level with the patient's eyes, and should be provided with a good light. The inner dial has groups of lines of various thicknesses on it, arranged in such a manner that in whichever way it is

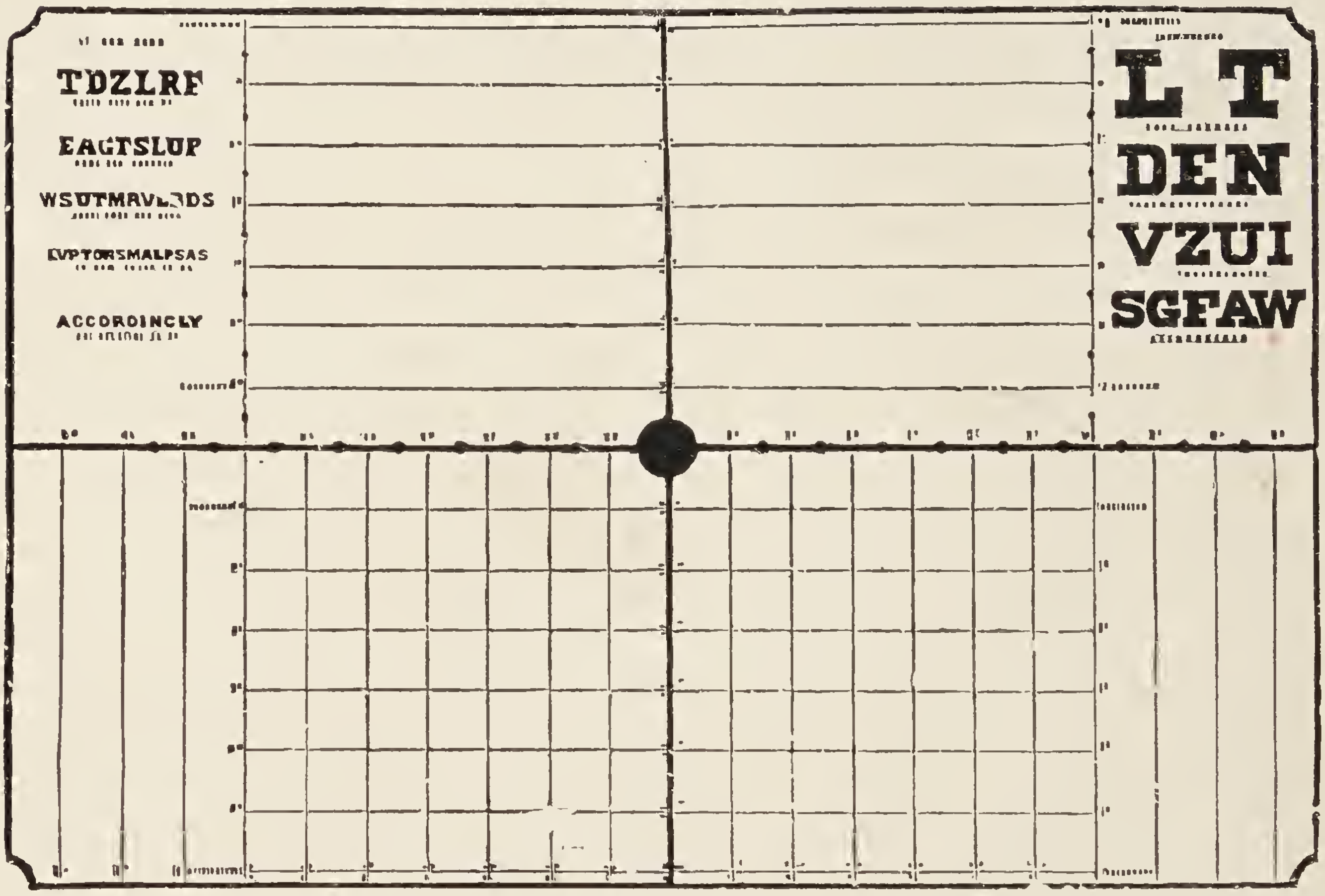
turned, there are always two groups of the same size exposed, opposite, and at right angles

Fig. 8.


DAVIDSON'S IMPROVED COMPLETE SIGHT TEST.
(GREAT PORTLAND ST LONDON. W.)
2L4A9E
5PF7LCA3
648 TEBLVDA
R74 ABUVDLNT
E
TV
LCA
EF6T
Z2B7A
VO8B5
10° 20° 30° 40° 50° 60° 70° 80° 90° 100° 110° 120° 130° 140° 150° 160° 170° 180°
ORANGE
GREEN
RED
PURPLE
MAUVE
YELLOW
SAGE GREEN
GREY
NOTE – THE OUTER DIAL PERMITS OF FOUR COLORS BEING EXPOSED AT ONE TIME
REVOLVING OUTER DIAL
OUTER DIAL
COVERING LINES AND COLORS
REVOLVING DIAL FOR ASTIGMATISM.
NOTE—THE OUTER DIAL PERMITS OF TWO SERIES OF LINES OF THE SAME THICKNESS BEING EXPOSED IN TWO OPPOSITE MERIDIANS AT ONE TIME

to each other. Under each set of lines is marked the distance in metres and feet at which the normal eye can count them. The outer dial has two openings that allow of only two sets of lines being exposed at one time. The radiating lines around the semicircle on the main card denote the Mns. at which the lines are exposed.

Fig. 9.



On each side of the main card are test letters and figures of various sizes, according to Snellen, and the dot tests for recruits. The reverse side of the card (Fig. 9) is arranged for testing defects of the ocular muscles (*heterophoria*), and for using with the Maddox multiple rods and prisms.

100. To use the dial and lines, find the Mn.

in which the smallest lines, or those normal for distance, are best counted, and then rotate dial forty-five degrees above and below it, to find if they can be counted better in any intermediate Mn.

101. Each eye should be examined separately, the opposite eye-piece of the trial spectacle frame being closed during the examination.

102. The distant V. should be first tested, then the near, and the muscular condition last. The patient is placed, if possible, 6 metres from the card, when the letters marked "V. = 6 m." should be read if V. is normal. If that distance cannot be obtained, then 4·5 m. must suffice, but the letters marked "V. = 4·5 m." should be read for V. to be normal. The largest type should be read at 60 m., the rest as marked under each: 36, 24, 18, 15, 12, 9, 6, 4·5 and 3 m.

103. Normal V. is described as being $\frac{6}{6}$, the upper figure or numerator representing the distance in metres at which letters can be read from; the lower figure or denominator representing the distance the smallest letters which can be read, should be read from. For instance, the letters which should be read at 6 m. cannot be read at that distance, but those which should

be read at 9 or 12 m. can be read. V. is then said to be $\frac{6}{9}$ or $\frac{6}{12}$.

104. If V. = $\frac{6}{6}$ and a cylinder makes it worse in every Mn., normal V. is confirmed.

105. Examination should always commence with + lenses, and every Mn. tested, before using — lenses. Stronger convex lenses (about 0·50 is generally enough), and weaker concave lenses should be used for *lines* than for *letters*, but only for that purpose, and are subsequently discarded.

106. In hypermetropic conditions the *strongest* convex lens, and in myopic conditions, the *weakest* concave lens, giving good V. should be used. In myopic conditions the use of convex lenses in every Mn. should be exhausted before using concave lenses. When a cycloplegic is used, allowance must be made accordingly. The correction in hypermetropia must be slightly reduced (by, say, + 1 D.), and in myopia by slightly increasing it.

107. The fact of lines being seen in any one Mn. better than in another, or the lines of letters which run in one direction better than those which run in another, is proof of the existence of astigmatism.

108. If improvement results in any one Mn.

with convex sphericals, it is a proof of hypermetropic astigmatism in that Mn.

109. When testing for astigmatism, spherical lenses should be used for *lines*, and cylindrical lenses for *letters*. And stronger + lenses, and weaker — lenses used for *lines* than for *letters.*

110. In compound astigmatism the spherical lens required is that which corrects the weakest er Mn.; the cylindrical lens, that which corrects the opposite; and the power of the latter, and the degree of astigmatism is equivalent to the difference between the two Mns. In mixed astigmatism the degree of astigmatism is the sum of both Mns.

111. The axis of the cylindrical lens should always be placed in the Mn. of G.D. *of the* eye *dial*. In placing the axis in this Mn., we really place it in the Mn. of L.D. *of the eye.*

The Pin-hole Disc.

112. If both near and distant V. be defective, the pin-hole disc will at once enable us to decide whether the fault is refractive or not. The minute hole in the centre should be placed in front of the centre of the pupil. If there be improvement the defect is refractive, and astigmatism may be suspected; but if there be

no improvement it is either the transparent media or the retinal sensibility that is in fault.

Cycloplegics.

113. Cycloplegics (κύκλος circle, πληγή stroke) produce paralysis of the ciliary muscles and of accommodation, and dilatation of the pupil. A *mydriatic* dilates the pupils.

114. The two cycloplegics in general use in estimating errors of refraction are *atropine* and *homatropine.* The former is generally used for young people, and should never be used for patients *over thirty-five years of age*; the latter, which is safer for adults, in whom only a modified effect is required, and owing to the length of time—about a week—during which the effects of atropine continue, few could put up with the inconvenience caused by it. For elderly people a 4-per-cent. solution of cocaine hydroch. will generally be found sufficient.

115. For subjective examination it is advisable, and for objective examination (retinoscopy) it is absolutely necessary to use a cycloplegic for astigmats, young squinters, and myopes *under sixteen*, also for hypermetropes under twenty, in order to make sure of completely paralysing

accommodation, and of allowing any spasm of the ciliary muscle.

116. A cycloplegic is seldom required for patients *over twenty-five years of age*, owing to the declining power of accommodation, but may be required even up to forty-five years in those with whom correction without a cycloplegic has failed to relieve the asthenopia.

117. The use of a cycloplegic is liable to produce glaucoma, especially in elderly people, and has not been unknown to have been produced in young people. To counteract this, its use should always be followed by an application of eserine, either in the form of lamella (0 cg. 013 = $\frac{1}{500}$ gr.), or a $\frac{1}{5}$ per cent. solution (6 cg. to 28 ml.). Care should always be taken previously to estimate the tension of the eyeball.

118. The cycloplegic may be applied to the inner surface of each lower eyelid, either in the form of lamellæ or in solution.

Under fifteen years of age.—One drop of the following solution, or one lamella, twice a day for three or four days previous to examination. In children, Mr. Hartridge recommends the continuance of the atropine till the spectacles are ready for use :

℞ *Atropini hydrobrom.* or *sulph.*
Cocain. hydrochlorid. āā 16 cg.
Aq. distil. ad 28 ml.
or *Lamella. atropin. hydrobrom.* and
Cocain. hydrochlor. āā 0 cg. 03.
(gr. $\frac{1}{200}$).

Over fifteen years of age.—One or two drops of the following solution, or one lamella, an hour before examination, and repeated in twenty minutes, when the patient is under twenty-five years of age: when over that age, one application half an hour previous will be sufficient. Cocaine not only increases the mydriatic effect, but tends to prevent *conjunctivitis:*

℞ *Homatropin. hydrobrom.* . 25 cg.
Cocain. hydrochlor. . . 32 cg.
Acid salicyl. . . . 6 cg.
Aq. distil. ad . . . 28 ml.
or *Lamella homatropin. hydrobrom.* and
Cocain. hydrochlor. āā 0 cg. 13 ($\frac{1}{50}$ gr.).

119. Complete paralysis of accommodation is effected in about three-quarters of an hour. The effects pass off in from twelve to twenty-four hours. In adults, when the examination is completed, one lamella or one drop of solu-

tion of eserine (117) should be applied, and repeated three times a day, until the sight for near objects becomes the same as before the test, which may be in two or three days. The patient should be provided with 10 to 15 lamellæ or drops for the purpose.

120. In astigmats, whatever the Mn. decided upon for the axis of the cylinder while under the influence of a cycloplegic, this must on no account be changed subsequently.*

121. The reading V. should not be tested until the effects of the cycloplegic have passed off, as, the accommodation being paralysed, the patient is unable to negotiate the divergent rays reflected from a book at a comfortable reading distance.

Spectacles.

122. When measuring for spectacles, care must be taken that the centres of the lenses correspond as nearly as possible with the centres of the pupils. Those intended for reading or

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[*] Care must be taken to make allowance for the influence of the cycloplegic, it being usually necessary slightly to reduce the correction in hypermetropes, and to increase it in myopes; by, say, ·75 if there is 1·5°, ·50 if 1·0°, 1·0 if there is 2·0°. A hypermetrope of + 3·5 would have + 1 D. less

near work only may be allowed to converge slightly.

123. Spectacle frames are measured from the outside rim of one eye-piece to the inside rim of the other, which measurement will be found to coincide exactly with the distance between the centres.

124. All glasses, except those for presbyopes, should be worn as close to the eyes as the lashes permit. The recognised distance is 13·7 mm. in front of the cornea. Presbyopes may wear them according to their own inclination, the distance from the cornea generally being about 2·5 cm. (or 1 in). Myopes should wear their glasses for reading and near work continually (55); hypermetropes (see 46, 47, and 76).

125. Spectacles are best in all cases, but if they are objected to, horizontal clips may be used for myopes and astigmats. Folders are only suitable for presbyopes and should never be used with astigmatic (cylindrical or compound) lenses. For presbyopes, who use glasses only for near work, spectacles are used for home work, while folders—which require only one hand to place them in position—are generally used for the pocket.

XIII. Preliminary Tests (on Letters only).

	Suspect	Go on to
126. i. Use *naked eye* (for acuteness of vision). Note result.		
ii. Use *convex sphericals* (for hypermetropia).		
(*a*) If V. normal or not, and there is improvement:	Hypermetropia	132
(*b*) If V. not normal, and partial improvement only.	comp. hyper. astig.	134
(*c*) If V. not normal and improvement doubtful, or no improvement at all—		
iii. Use *convex cylinders* (for hypermetropic astigmatism and myopia). Rotate starting ↓.		
(*a*) If one Mn. improved, and the opposite made worse (because probably emmetropic), but normal V. obtained with this lens alone:	simple hyper. astig.	133

	Suspect	Go on to
(*b*) If one Mn. improved, opposite made much worse, but normal V. not obtained with this lens alone:	mixed astig.	135
(*c*) If equally worse in every Mn.:	myopia	136
(*d*) If worse in every Mn., but more so in one Mn. than in another—		
iv. Use *concave cylinders* (for myopic astigmatism). Rotate starting →		
(*a*) If one Mn. improved (the Mn. made worse with convex cylinders); the opposite made worse (because probably emmetropic); and normal V. obtained with this lens alone:	simple myopic astig.	137
(*b*) If one Mn. improved, but normal V. not obtained with this lens alone:	comp. myopic astig.	138
v. There being no refractory error, or a trivial one only; or normal V. not obtained during any of the above tests:	heterophoria.	§ XV

XIV. CONFIRMATORY TESTS.

HYPERMETROPIC TESTS.

Hypermetropia.

127. Whether letters read or not read normally, if V. is good or improved with spherical convex lens, the diagnosis of hypermetropia is complete.

Correction: The strongest spherical convex which gives best results (106).

Simple Hypermetropic Astigmatism.

(See 108 and 109.)

128. Having noted the defective Mn., say 15°, which was improved with cylindrical convex lenses, say 1·0, on letters, verify this Mn. on lines, exposing those normal for distance, and add a further + 0·5 to the above lens = 1·5 (105). This angle will be found to correspond with the defective Mn. Then test the opposite Mn., 105°, on lines with the naked eye, and if V. is normal the diagnosis is complete.

Correction: The strongest convex cylinder

(45) with which letters can be read at normal distance, axis in defective Mn. (111).

Formula: Cyl. + 1·0, ax. 15°.

Compound Hypermetropic Astigmatism.

129. Having noted the strength of the spherical convex lens, say 1·5, which gave partial improvement only on letters, proceed to find the Mn. of G.D., *i. e.* the most hypermetropic (63). To the above lens add a further 0·5 = sph. + 2·0 (105), and test on lines. Commence by exposing largest lines, gradually reducing the size until the least is found that can be counted. Then find the Mn. in which they are best seen—say 15°—by rotating the disc. This is the Mn. of G.D. Discard this lens. Then test lines in the oposite Mn. (that at right angles to it), the Mn. of L.D.—105°. If found to be hypermetropic, the diagnosis is complete. The condition of this Mn. will show whether it is a case of *simple* or *compound hypermetropic*, or *mixed astigmatism.* Now use the naked eye; then add convex spherics till the strongest is found which gives best results, say + 0·50. This will be the *spherical* correction.

Result: Sph. + 0·50 in meridian 105°.

With the above lens (sph. + 0·50) draw

attention to letters and place in front of the eye cylinders with axes in Mn. of G.D. (15°), till the one is found which gives the best results, say + 1·0. This is the *cylindrical* correction.

The *total* correction is the sum of the two lenses, and the *formula:* Sph. + 0·50 $\overset{\frown}{\smile}$ cyl. + 1·0 ax. 15°. We have thus + ·50 D. in Mn. 15°, and + 1·50 D. in Mn. 105°.

Confirm by rotating the cylinder to either side.

Mixed Astigmatism.

130. Having noted the Mn. which was improved with the convex cylinders on letters, say horizontal, we diagnose *hypermetropic astigmatism* in this Mn. (109). To complete the examination, test the opposite Mn., the vertical (which gave the best results with the naked eye, and was made much worse with the *weakest* convex lens), with weak concave cylinders on letters, axes in this Mn. *Myopia* will at once be made manifest. Now proceed to find the *amount* of defect in each Mn.

Expose lines on dial, normal for distance: (*a*) First test the hypermetropic Mn. (the horizontal) by rotating the dial, and placing lines in that Mn., with convex sphericals. The strongest with which the lines can be counted denotes the *amount of hypermetropia*, say + 2·0. (*b*) Then test the myopic Mn., the vertical, by placing lines in that Mn., with concave sphericals. The weakest with which the lines can be counted denotes the *amount of myopia*, say — 1·0.

Total result: Hypermetropia of + 2·0 in the horizontal Mn. and myopia of – 1·0 in the vertical Mn. The sum of the two denotes the *amount of astigmatism*, and the strength of the cylindrical lens required.

Correction: Cyl. + 2·0, ax. h., ○ cyl. – 1·0, ax. v., which reduced to a spheric and a cylinder, give the following:

Formula: Sph. + 2·0 ○ cyl. − ~~+~~ 3·0, ax. v.

The sph. + 2·0 corrects the hypermetropia in the horizontal Mn., but makes the myopia in the vertical Mn. more myopic, by — 2·0, than before, which is corrected by — 3·0.

Alternative formula: Sph. — 1·0 ○ cyl. + 3·0 ax. h.

Here the sph. – 1·0 corrects the myopia in the vertical Mn., but makes the hypermetropia in the horizontal Mn. more hypermetropic by — 1·0, necessitating + 3·0 instead of + 2·0 D. to correct it.

MYOPIC TESTS.

Myopia.

131. Test (*a*) with the naked eye on lines. *Result:* V. equally bad in every Mn. (*b*) With concave sphericals on letters. *Result:* V. normal with this lens alone. The diagnosis of myopia is complete.

Correction: The weakest concave spherical that gives the best results.

Simple Myopic Astigmatism.

132. V. is made worse in every Mn. with convex cylinders.

Test with naked eye on lines. *Result:* V. $= \frac{6}{36}$. Lines in one Mn., say the horizontal, are corrected normally, but those in the opposite Mn., the vertical, cannot be corrected. Then test the lines in the opposite Mn. with weak concave cylindricals, axis in this Mn.

Result: V. $= \frac{6}{6}$, and the diagnosis is complete.

Correction: The weakest concave cylindrical, say − 0·5, with which lines can be counted normally, axis in defective Mn. (the vertical). Verify on letters.

Formula: Cyl. − 0·5, ax. v.

Compound Myopic Astigmatism.

133. There was no improvement with convex lenses. One Mn. improved with concave cylinders, but normal V. not obtained with this lens alone.

Test (*a*) with the naked eye: V. = $\frac{6}{36}$; lines not counted in any Mn. (*b*) With concave sphericals, say 2·0 on letters, find the weakest giving best results. Then change lens to 0·5 less (106) = sph. – 1·5, and find the Mn. of L.D., which is the Mn. in which lines are best counted, say the horizontal. The weakest is the *spherical correction*, say, – 1·0 D. Test the opposite Mn., the horizontal, for the *cylindrical correction.* To the spherical correction – 1·0, add cylindrical lenses, say 2·0 D., axis in Mn. of greatest defect (the vertical), and find the weakest with which letters can be read and lines counted in both Mns. at normal distance.

Formula : Sph. – 1·0 $\bigcirc$ cyl. – 3·0, ax. v. We have here – 1·0 D. in the V. Mn., and – 3·0 in the H. Mn.

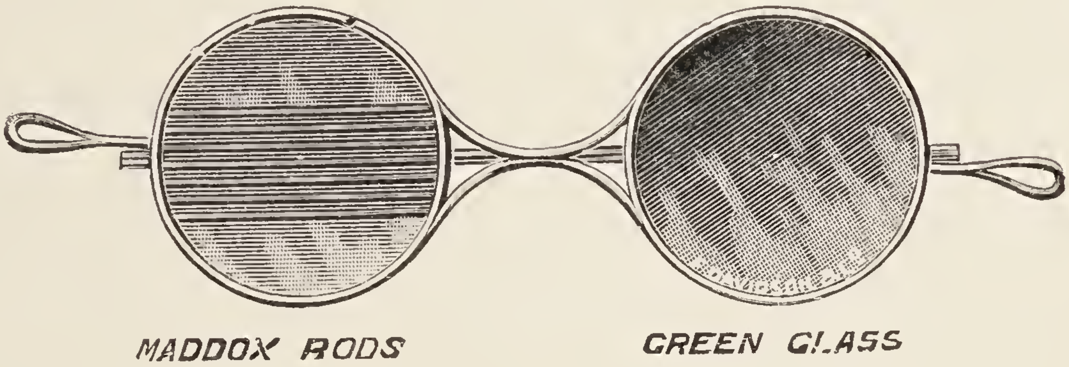
XV. HETEROPHORIC TESTS.

(*a*) *The Distant Point Muscle Test.*

(With the Maddox Multiple Rods.)

134. The eyes must be examined with both distant and near point tests, the former first, then the latter. Both eyes are kept open during the examination. The refractive condition, if any, should be first discovered and the correction worn during the test.

Fig. 10.



135. The disc of the Maddox rods fits sufficiently loosely in one of the frames that it may be rotated with the finger and thumb, bringing the rods into either a *horizontal* or *vertical* position; in the opposite frame is coloured glass. The spectacle frame can also be reversed for the use with either eye. There are two methods of using the rods, which are explained in the two following sections.

136. The frame containing the rods is placed in position, the rods being at first horizontal and the patient's attention concentrated on a light placed in front. The light when seen through the Maddox rods (Fig. 10) under a condition of perfect equilibrium (*orthophoria*) is seen as a long red streak through the middle of the flame, but in the opposite Mn. to that in which the rods are placed—vertically when they are placed horizontally (Fig. 11, *a*), and horizontally when they are placed vertically (*b*). Any variation in the position of the streak to either side shows want of harmony between the convergence and accommodation, and heterophoria in some form or another will be found to exist. If the streak is seen with the right eye to the right of the flame and with the left eye to the left, convergence (*esophoria*) exists; if the reverse, divergence (*exophoria*) exists. Now place the rods *vertically*; if the streak appears *below* the flame, left hyperphoria exists, and if *above*, *right hyperphoria*. The amount of deviation in each case is gauged by the prism which brings the streak into its normal position.

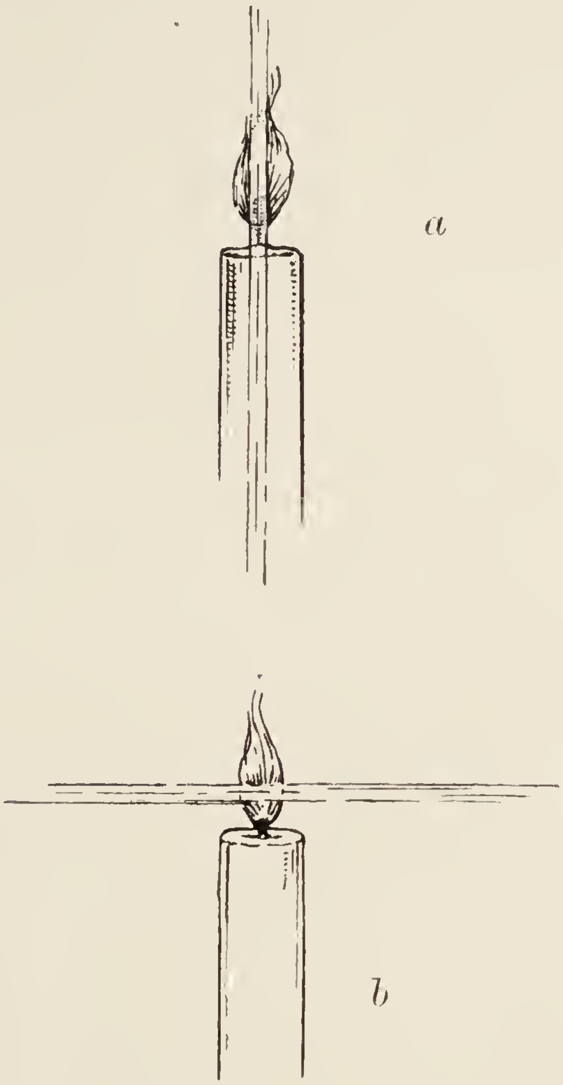
These above are the [illegible] lenses

These below the [illegible]

137. The sight-test card (Fig. 9) is brought into use, the central black spot being on a line

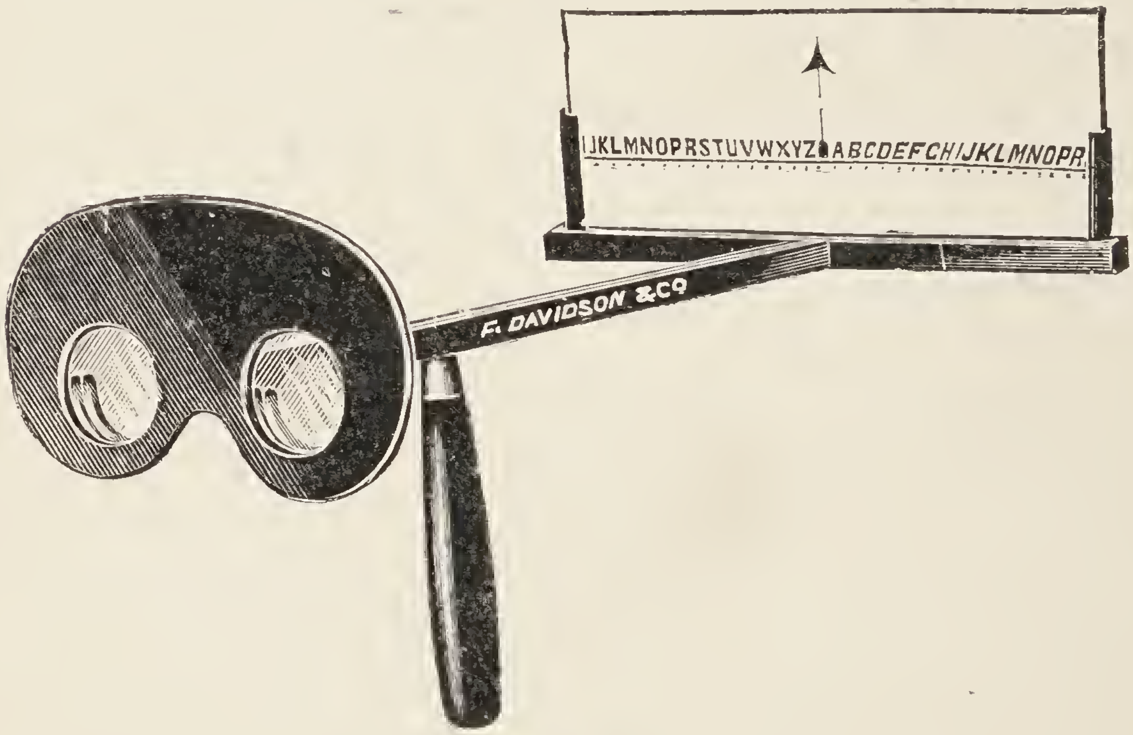
with the eye. A light is then placed in front of the spot and the patient placed 3 metres distant (the distance for which the scale is graduated). Looking through the rods—placed horizontally for esophoria and exophoria, vertically for hyperphoria—the streak is seen as in the previous method. The approximate amount of deviation will be noted by the numbers at the head of the vertical lines and at the sides of the horizontal lines nearest the streak.

Fig. 11.



138. Where refractive error exists with heterophoria, the effect of correcting the former should be tried first before resorting to prismatic correction, as it is possible that the heterophoria may be produced by the former. If the muscular asthenopia still persists, prisms may then be resorted to.

Fig. 12.



(*b*) *The Near Point Muscle Test.*

139. The near point muscle test (Fig. 12) is a frame in which is inserted a pair of prisms, bases up for one eye, bases down for the other. The rod carries a small card at a distance of 25 cm. The appliance is held by the handle in front of the eyes, the rod between the eye-

piece and the card being perfectly horizontal. The patient then looks at the card, diplopia resulting, and two lines of letters and two arrows are seen, one set below the other. If muscular conditions are normal the lower arrow will be seen immediately below the upper one. He is then asked to which side of the upper arrow the lower one appears, and under which letter. If to the right, there is latent convergence (*esophoria*); if to the left, latent divergence (*exophoria*). The degree marked under the letter denotes approximately the angle of the prism required to produce normal conditions and bring the lower arrow exactly beneath the upper. It is generally advisable to follow up this diagnosis by confirming it with the prism.

140. The correcting prism should be placed with its base in the same direction as the streak appears, in relation to the light, *out* in esophoria, *in* in exophoria. It will then bring the streak into its true position and show the amount of deviation.

Corrections for Heterophoria.

141. If the aggregate muscular deficiency in both eyes is less than 16°, one-fourth of the total

amount for each eye is the maximum or limit. The limit should never be given at first, but about one-third; and it is never advisable to use a stronger prism than 4°.

For esophoria and exophoria: The amount of correction required is found in the following manner. Suppose we have 6° of deficiency in each eye, the sum would be 6 + 6 − 4 = 8, which would be the extreme of prismatic force allowable for correction. It is usual to give only one-third of this at first. The formula would be: B.E. prisms 1° for esophoria, bases OUT, and for exophoria the same, but bases IN.

For esophoria with hypermetropia: The convex lens corrects both defects, for while improving the hypermetropia, it improves also the esophoria. The full correction of the refractive error is therefore given. The glasses to be worn constantly. No prisms.

For esophoria with myopia: The full correction for the myopia to be given. Prisms, bases out. Near work to be given up for a time.

For exophoria with hypermetropia: Less than the full correction of the hypermetropia to be given. The convex lens, while correcting the hypermetropia, aggravates the exophoria by increasing the divergence of the visual axes.

The prisms, bases in, to be kept as weak as possible.

For exophoria with myopia: The myopia to be fully corrected. Prisms, bases in.

For exophoria with presbyopia: The weakest convex lens to be given. Prisms, bases in.

For hyperphoria: The amount of deviation in each case is shown by the number on the card nearest to the streak, and by the prism in front of the rods which brings the streak through the middle of the light.

142. On first wearing prismatic glasses some discomfort may be experienced, for two or three weeks perhaps, but the patient will gradually become accustomed to them.

143. In *exophoria* cases a great deal can be done by the use of *muscular exercises* in order to strengthen the *internal recti* muscles. One method is for the patient to fix both eyes upon the finger or a pencil held up at arm's length, while slowly bringing it nearer. The closer it is approached the greater is the effort of convergence. As soon as diplopia results, the finger or pencil must be receded and the test commenced again. This should be repeated several times at each practice, which may be attempted twice or three times a day. The

patient may vary this proceeding with frequent attempts to look at the end of his nose. Another method—which the medical attendant must undertake himself—is to practise with prisms. The patient is directed to look intently at a light, when prisms of gradually increasing strength, with bases out, are placed in front of the eyes until the strength is found with which binocular V. can be maintained. While doing so, the prisms should be raised from the eyes for a few seconds and replaced, when two lights will probably be seen, which, as the power of convergence comes into play, will gradually be merged into one another. This practice should be repeated daily until a prismatic power of 15° for each eye is reached.

XVI. PRESBYOPIC TESTS.

Presbyopia.

144. The lenses generally required are:

At age .	45	50	55	60	65	70
Dioptres .	·75	1·5	2·5	3·5	4·0	4·5

145. The distant vision should always be tested first to detect hypermetropia, myopia or astigmatism. Note the result, and test the near vision with the reading-type to find the

p.p., which should not be done too hurriedly. If hypermetropia exists, the amount of defect must be added to the presbyopic defect; if myopia exists, it must be subtracted.

Correction for the emmetrope: Having found the distance of the p.p. deduct this from the lens, the focus of which represents the points we wish to make the p.p., say, 30 cm. Thus, the p.p. has receded to, say, 50 cm. The lens representing this point is sph. + 2 (10). To bring the p.p. to 30 cm., $\frac{100}{30} = 3{\cdot}3$, the nearest lens being 3·5, we shall require sph. + 1·5. Confirm the correction with the reading-type.

Presbyopia with Hypermetropia.

146. Having tested the distant vision with lenses that correct the hypermetropia, add to this the additional lens necessary for reading. The lenses which correct the hypermetropia only are to be worn constantly, while separate glasses must be used for reading.

Presbyopia with Myopia.

147. The same process is gone through, and the same remarks apply, as in the preceding section, except that concave instead of convex lenses must be used (56).

Presbyopia with Hypermetropic Astigmatism.

148. Add to the lens that corrects the hypermetropic astigmatism, spherical lenses that correct the presbyopia. For instance, a patient of fifty years of age requires for distance, sph. + 2 with cyl. + 2·0 ↓. On account of his age he would require for reading, sph. + 1·0, but being a hypermetrope he will probably require 1·5, for hypermetropes manifest more presbyopia than emmetropes. He would therefore require for reading sph. + 3·5 ○ cyl. + 2·0 ↓, the distant correction remaining the same for both distance and reading.

Presbyopia with Myopic Astigmatism.

149. In myopic astigmatism of 2·5 or less, first reverse the cylindrical correction for distance; and if this is not sufficient to allow of small print being read near enough, add the weakest convex spherical lens giving normal V. A patient fifty years of age requires for distance, cyl. — 1·0 ↓; for his presbyopia he requires sph. + 1·0 = cyl. + 1·0 →. In myopic astigmatism of over 2·5 D., give a convex spherical with the same concave cylinder required for distance.

Presbyopia with Compound Myopic Astigmatism.

150. Suppose that there is myopia in the vertical Mn. of 1·5, and in the horizontal Mn. of 0·75, the correction for distance is sph. — 0·75 ○ cyl. — 0·75 ↓. There is therefore in the horizontal Mn. — 1·5 and in the vertical — 0·75. If the patient is fifty years of age, correct the presbyopia, say 1·0, by making the vertical Mn. as myopic as the horizontal, and by giving a cyl. + 0·75 ↓. The patient is now equally myopic in every Mn., which is sufficient at that age. At sixty to sixty-five years of age give cyl. + 0·75 →, which makes the patient equally myopic to 1·5, and if this is not sufficient, add the weakest convex spherical that will enable him to read. It is well to bear in mind the distance of the p.r. for reading when making the patient equally myopic in every Mn., for when giving a convex cylinder in order to effect the above purpose the p.r. may be too near for reading. A patient requires cyl. — 4·0 D. ↓; the cylinder is reversed, giving cyl. — 4·0 →, making him equally myopic in every Mn., but with a p.r. at 25 cm., which is too near.

Presbyopia with Mixed Astigmatism.

151. The correction is the same as in presbyopia with myopic astigmatism, when the myopia required 2·5 or less. First make the patient equally myopic by giving a convex cylinder, axis in the hypermetropic Mn., of the strength of the hypermetropia and the myopia combined. When the myopia is more than 2·5, retain the concave cylinder and add a convex spheric, to give comfortable reading sight.

PART III

XVII. OBJECTIVE SIGHT-TESTING—"RETINOSCOPY."

(*General.*)

152. To obtain a knowledge of retinoscopy, or objective sight-testing, called also "the shadow test," the model eye will be found useful, but practice upon the eye itself is essential.

153. It is useful in cases of astigmatism of low degree in amblyopia, where the visual acuteness remains below normal, and is an unfailing test against malingering. For it to be successful the transparent media should be clear and there should be no photophobia.

154. It is better if possible for the pupils to be dilated and accommodation paralysed by a cycloplegic (118).

155. The right eye should be tested first, the

opposite eye-piece of the trial frame being closed.

(*Mode of Examination.*)

156. The patient is seated in a dark room, with a light (a 32 Watt electric lamp, an Argand gas burner, or an oil lamp) behind and above him, so that his face is placed in shadow, and wearing the trial spectacle frame. The operator (wearing his correcting glasses if his distant vision is faulty), with an ophthalmoscopic plane mirror in his hand, seats himself facing the patient, the eyes of both being on the same plane, and at a distance of 120 to 150 cm.* The patient, *if under* the influence of a cycloplegic, is directed to look steadily at the central hole in the mirror; *if not under* such influence, is directed to look beyond the mirror slightly inwards towards his nose, but on no account must he look directly at the mirror. The operator, holding the mirror in position opposite the light, looks through the central opening,

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* In former days a concave mirror was used, when it was necessary for the operator to sit closer, but this is now almost universally discarded for the plane mirror, which gives a true image of the fundus, and by which shadows are better seen and the results more exact. If, however, a concave mirror be used, the resulting shadow in every case moves in the reverse direction.

and throws the reflection upon the patient's retina, the small illuminated portion of which is termed the "red" or "fundus reflex"—bright in the emmetrope, but less so in the ametrope—when the shadow surrounding it must be carefully looked for and watched, for it is by the direction in which the shadow moves when the mirror is revolved that the case can be correctly diagnosed.

157. The image of the reflected light in hypermetropia is an erect one formed *behind* the eye, whereas in myopia it is an inverted one formed *in front of* the eye.

TESTING THE SHADOW.

158. Both Mns. must be examined separately, first by revolving the mirror on its vertical axis for the horizontal Mn., then on its horizontal axis for the vertical Mn.

159. When the mirror is revolved (on either axis): (1) If the shadow moves "with" it, *i. e.* in the same direction as the circle of light, the refractive defect is *hypermetropic*; (2) if the shadow moves "against" it* the refractive

---

* Provided the operator is not nearer than the patient's p.r., for in low degrees of myopia, say — 5 D., where the p.r. is beyond 120 cm., the shadow will move "with."

defect is *myopic* ; (3) if the shadow is neutralised and appears to rapidly turn over with the mirror the eye is *emmetropic* ; (4) if the refraction in the two Mns. differs *astigmatism* exists.

160. The slower the shadow is in moving the less distinct it is, and the duller the reflex, the *higher is the degree* of ametropia. The quicker the shadow moves the more distinct it is, and the brighter the reflex, the *lower is the degree* of ametropia.

161. The refractive defect (if any) being discovered, proceed to find the amount in either or both Mns. by putting up in the trial-frame a neutralising lens, commencing with 1 or 2 D., and continue changing them according to whether they over- or under-correct the movement of the shadow. In high degrees of ametropia the red fundus reflex is generally obscured and the shadow difficult to make out. A + 6 D. may be put up ; then a — 6 D. With one or the other the ametropia will be more or less corrected and the shadow seen without difficulty. From this point the examination can be easily completed.

162. In astigmatism the illuminated area (*i. e.* the image of the light) may vary both in shape and position, being dependent upon

the maximum and minimum curvature of the cornea, being sometimes oval, and at others band-like in shape, and the edges horizontally, vertically, or obliquely disposed. The line of obliquity of the oval or band denotes the direction of the chief Mn., with which either is parallel.

163. In cases of *compound astigmatism* the vertical Mn. should be corrected first.

164. In *irregular astigmatism* retinoscopy does not give satisfactory results, the shadow being indefinite and irregular.

165. In *conical cornea* the shadow is ring-shaped.

166. Having found the correcting lens which neutralises the shadow, for each eye in hypermetropia and myopia, and for each Mn. in the case of astigmatism, the combination having been first put up in the trial frame, the test is confirmed by testing the distant vision subjectively with the trial card, making any alteration which may be necessary.

167. In estimating a patient's refraction by retinoscopy we must bear in mind that we do so as if his p.r. was at 150 cm., the distance between him and the operator, and his hypermetropia will be *over*- or his myopia *under*-

72

were

estimated, as the case may be. To obviate this in the former case we deduct + 1 D., and in the latter we add – 1 D. to his correction. For instance, if the shadow moves with the mirror, and + ·50 corrects, the case is one probably of weak myopia; if + 1 D. corrects, the eye is emmetropic; and if a stronger lens is required the case is one of hypermetropia. If, however, the shadow moves against the mirror it is obviously a case of myopia, and if we get no shadow we may conclude we are practically sitting at the patient's far point.

XVIII. EXAMPLES.

HYPERMETROPIA.

168. The shadow is "with" the mirror. A + lens, say, + 1 D., is put up in the trial frame. If the shadow is still "with," this is changed for + 2 or + 3, and so on till the shadow is neutralised.

Formula: $\begin{array}{c|cl} \text{———} & \text{———} & +3 \\ & +3 & \end{array}$

MYOPIA.

169. The shadow is "against" the mirror. A – 1 D. lens is put up in the trial frame. If

the shadow is still "against" this is changed for − 2, and so on till the shadow is neutralised.

Formula : $\begin{array}{c|l} \rule{2em}{0.4pt} & \rule{2em}{0.4pt}\ -2 \\ & -2 \end{array}$

Simple Hypermetropic Astigmatism.

170. The shadow in the two chief Mns. differs. That in the vertical Mn. is emmetropic, but that in the horizontal requires + 3 D. to neutralise.

Formula : $\begin{array}{c|l} \rule{2em}{0.4pt} & \rule{2em}{0.4pt}\ +3 \\ & \text{Em.} \end{array}$

Compound Hypermetropic Astigmatism.

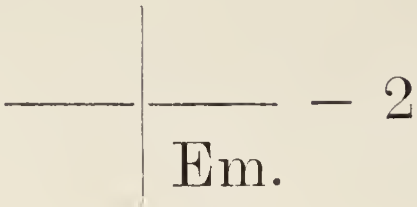
171. The shadow in one Mn., say the vertical, may be corrected with, say, + 2 D., while in the opposite Mn. it is still "with." It is then apparent that both Mns. are defective, but in a different degree, the shadow in the horizontal Mn. requiring + 3 D. to neutralise.

Formula : $\begin{array}{c|l} \rule{2em}{0.4pt} & \rule{2em}{0.4pt}\ +3 \\ & +2 \end{array}$

Simple Myopic Astigmatism.

172. The shadow in one Mn. is "against," the opposite being emmetropic.

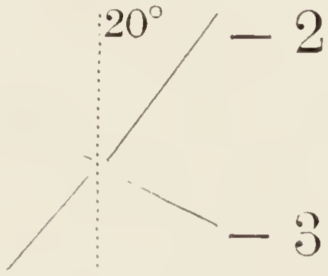
Formula :



Compound Myopic Astigmatism.

173. The shadow is oblique. Astigmatism is manifest. Correct each Mn. separately, moving the mirror *at right angles to the edge of the shadow.* The amount of obliquity can generally be estimated by the eye. If the vertical meridian be 20° out and requires for its correction – 2 D., and the Mn. at right angles to this requires – 3 D., it is expressed as in the following formula.

Formula ;

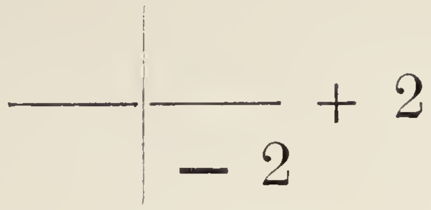


Correct with sph. – 2 ◯ cyl. – 1 ax. 110°.

Mixed Astigmatism.

174. The shadow on vertical rotation is neutralised by a + 2 D. for the horizontal Mn., while on horizontal rotation for the vertical Mn. requires – 2 D.

Formula :



Correction.—A cyl. − 2, ax. h. ○ cyl. + 2 ax. v. But as it is a rule in correcting refractions to reduce to a sphere and a cylinder, either of the following formulæ may be adopted, the latter for preference.

1. Sph. − 2 ○ cyl. + 4, ax. v. ; or—
2. Sph. + 2 ○ cyl. − 4, ax. h.

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D = 0,5.

It is counted by some a weakness in Princes to have Favourites; but it is of all others the best remedy against Ambitious Great Ones.

D = 0,6.

For when the way of pleasuring and displeasuring lieth by the Favourite, it is impossible any other should be Over-great. Another means to curb them, is to balance them by others as proud

D = 0,8.

But then there must be some middle Counsellors to keep things steady; for without that Ballast the Ship will roll too much. At the least, a Prince may

D = 1.

As for the having of them obnoxious to ruine, if they be of fearful Natures, it may do well; but if they be Stout and Daring, it may precipitate their Designs, and prove Dangerous. As for

D = 1,25.

As for the pulling of them down, if the Affairs require it, and that it may not be done with safety suddenly, the only way is, the interchange continually of Favours and Disgraces; whereby they may

D = 1,5.

Of Ambitions, it is less harmful the Ambition to prevail in great things, than that other to appear in every thing; for that breeds confusion, and mars business. But yet it is

D = 1,8.

He that seeketh to be eminent amongst able Men, hath a great task; but that is ever good for the Publick; but he that plots to be

D = 2,1.

Honour hath three things in it: The Vantage Ground to do good, the approach to Kings and Principal

D = 2,6.

He that hath the best of these Intentions when he aspireth, is an honest Man; and

D = 3,6.

And let them discern a busy Nature from a

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